# PROCEEDINGS

OF

# THE ROYAL SOCIETY.

*January* 7, 1886.

Professor STOKES, D.C.L., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The following Papers were read :—

## I. "Experimental Researches on the Propagation of Heat by Conduction in Muscle, Liver, Kidney, Bone, and Brain." By J. S. LOMBARD, M.D., formerly Assistant Professor of Physiology in Harvard University. Communicated by CHARLES E. BROWN-SÉQUARD, M.D., LL.D., F.R.S. Received December 7, 1885.

(Abstract.)

The apparatus employed in the present investigations was the same thermo-electric one that was used in the experiments on conduction of heat in bone, brain-tissue, and skin, described in a former paper,* but the mode of application of the thermo-pile to the tissue was somewhat different. The tissue, whether hard or soft, was placed on a thin copper plate, which formed the floor of a square hole cut in the bottom of a small light wooden box. The pile, having been applied to the upper surface of the tissue, was held in place by means of a pasteboard collar, which was made fast with pins to the edges of the box. In the case of the soft tissues, light weights were affixed to the pile to regulate the pressure. With bone, in order to insure intimate contact between the pile and the tissue, and between the latter and the copper plate, a little marrow was used. The unoccupied space in the box was filled with finely chopped cotton-wool. The box had pasteboard uprights attached to its sides, by which it was suspended from the

* "Proc. Roy. Soc.," vol. 34, pp. 173, 198.

sliding arm of a stand. The inferior surface of the copper plate was brought in contact with water of a temperature lower than that of the air by fractions of a degree of centigrade, as in the former experiments referred to.

*Experiments on Muscle.*

The muscles examined were those of the head, thigh, and leg of the sheep.

It soon was noticed that the rate of transmission differed somewhat, according as the muscle was examined in the direction of its fibres or perpendicularly to them; and this fact led to the division of the experiments into two classes, according as the line of conduction was parallel or at right angles to that of the fibres.

Tables I and II give results obtained under these two conditions respectively. The results represent 104 observations on conduction parallel to the direction of the fibres, and 100 observations on conduction at right angles to this direction.

Table I.—Conduction of Heat through 10 mm. of Sheep's Muscle, parallel to the direction of the Fibres.

| Time. | Percentages of heat transmitted. | | |
|---|---|---|---|
| | Averages. | Maxima. | Minima. |
| At the end of 4 minutes........ | 33·985391 | 58·359600 | 19·959500 |
| ,, 6 ,, ........ | 51·215703 | 77·219200 | 34·712200 |
| ,, 9 ,, ........ | 66·775211 | 93·108500 | 49·133700 |
| Permanent thermal condition ... | 82·730123 | 99·500000 | 63·557000 |

Table II.—Conduction of Heat through 10 mm. of Sheep's Muscle, perpendicular to the direction of the Fibres.

| Time. | Percentages of heat transmitted. | | |
|---|---|---|---|
| | Averages. | Maxima. | Minima. |
| At the end of 4 minutes........ | 27·038177 | 40·837000 | 11·373300 |
| ,, 6 ,, ........ | 40·701253 | 60·789900 | 26·283600 |
| ,, 9 ,, ........ | 58·174220 | 84·384200 | 39·203600 |
| Permanent thermal condition ... | 76·614920 | 99·422300 | 50·911200 |

It will be seen that parallel conduction shows the higher per-

centages—average, maximum, and minimum—at every period. The average percentages of superiority of parallel conduction over conduction at right angles are as follows:—

| At the end of 4 minutes. | At the end of 6 minutes. | At the end of 9 minutes. | Permanent thermal condition. |
|---|---|---|---|
| 6·947214 .... | 10·51445 .... | 8·600991 .... | 6·115203 |

The conductivity of muscle, unlike that of the other tissues examined, does not appear to depend, at least in any marked manner, upon the degree of freshness of the tissue. So long as the muscle is kept in a moist state, it seems to conduct equally well whether recently removed from the animal or after decay has commenced; and when the conductivity has been decidedly lowered by exposure to the air, it generally can be partially, and sometimes completely, restored, by moistening the tissue with water or fresh animal juices.

### *Experiments on Liver.*

The liver examined was that of the sheep. Table III gives the results of sixty experiments on this organ.

Table III.—Conduction of Heat through 10 mm. of Sheep's Liver.

| Time. | Percentages of heat transmitted. | | |
|---|---|---|---|
| | Averages. | Maxima. | Minima. |
| At the end of 4 minutes........ | 45·628640 | 61·618700 | 27·367800 |
| ,, 6 ,, ........ | 64·338080 | 79·448900 | 48·352500 |
| ,, 9 ,, ........ | 81·164906 | 93·171900 | 64·383800 |
| Permanent thermal condition ... | 93·043060 | 99·500000 | 78·004000 |

The conductivity of liver diminishes steadily and rapidly after death, and is not restored by moisture or fresh animal matter, although these latter seem to reduce the rate of loss.

### *Experiments on Kidney.*

The observations were made on sheep's kidney. Tables IV and V give respectively the results of thirty experiments on the cortical substance, and of an equal number on the medullary tissue.

The tables show that at every period of the observations, excepting the maximum for the ninth minute, which gives a slight balance in favour of the medullary tissue—the cortical tissue is the better conductor.

Table IV.—Conduction of Heat through 10 mm. of the Cortical Substance of Sheep's Kidney.

| Tii | Percentages of heat transmitted. | | |
|---|---|---|---|
| | Averages. | Maxima. | Minima. |
| At the end of 4 minutes........ | 44·512983 | 53·013900 | 27·725100 |
| " 6 " ........ | 64·946250 | 72·318700 | 59·696400 |
| " 9 " ........ | 82·431483 | 87·027000 | 78·138000 |
| Permanent thermal condition ... | 97·715600 | 99·500000 | 93·466600 |

Table V.—Conduction of Heat through 10 mm. of the Medullary Substance of Sheep's Kidney.

| Time. | Percentages of heat transmitted. | | |
|---|---|---|---|
| | Averages. | Maxima. | Minima. |
| At the end of 4 minutes........ | 36·541850 | 46·861700 | 19·867800 |
| " 6 " ........ | 56·686350 | 69·645700 | 39·955000 |
| " 9 " ........ | 71·536316 | 87·121000 | 53·310900 |
| Permanent thermal condition ... | 91·947716 | 98·676300 | 78·150400 |

Both cortical and medullary substances behave like liver as regards the diminution of conductivity after death, and the effect of water and fresh animal matter on this loss.

*Experiments on Bone.*

The observations were made on the tibia and the ilium of the sheep. The experiments were divided into three classes, according as the tissue was compact, spongy or combined compact-spongy. Some 200 experiments were made, which were divided about equally between the three varieties of tissue.

Tables VI, VII, and VIII give the results of these experiments. According to the tables, spongy tissue stands first in average, maximum, and minimum conductivity, at every period, and the combined compact-spongy tissue comes next, also as regards all three valuations and every period of time.

Table VI.—Conduction of Heat through 10 mm. of the Compact Tissue of the Head of Sheep's Tibia.

| Time. | Percentages of heat transmitted. | | |
|---|---|---|---|
| | Averages. | Maxima. | Minima. |
| At the end of 4 minutes........ | 24·067400 | 30·377800 | 16·106900 |
| " 6 " ........ | 36·305560 | 40·411400 | 30·831300 |
| " 9 " ........ | 47·959167 | 54·529600 | 35·357000 |
| Permanent thermal condition ... | 70·770483 | 75·717700 | 56·179500 |

Table VII.—Conduction of Heat through 10 mm. of the Spongy Tissue of the Head of Sheep's Tibia.

| Time. | Percentages of heat transmitted. | | |
|---|---|---|---|
| | Averages. | Maxima. | Minima. |
| At the end of 4 minutes........ | 35·939917 | 54·671700 | 21·894200 |
| " 6 " ........ | 52·274800 | 74·495300 | 31·398500 |
| " 9 " ........ | 70·911200 | 89·498600 | 41·547200 |
| Permanent thermal condition ... | 89·779800 | 97·225600 | 62·436700 |

Table VIII.—Conduction of Heat through 10 mm. of Sheep's Ilium. Compact and Spongy Tissues combined.

| Time. | Percentages of heat transmitted. | | |
|---|---|---|---|
| | Averages. | Maxima. | Minima. |
| At the end of 4 minutes........ | 32·736216 | 45·292000 | 18·351600 |
| " 6 " ........ | 48·374200 | 64·755300 | 31·195800 |
| " 9 " ........ | 61·197667 | 81·495700 | 40·602900 |
| Permanent thermal condition . | 74·741783 | 95·458500 | 59·718700 |

Both compact and spongy tissues lose their conducting power more or less rapidly after removal from their natural surroundings; spongy tissue much more quickly than compact. Spongy tissue may regain the greater part of the loss of its conductivity, after the application of water or fresh animal matter, but this is not the case with compact

tissue; however, moisture seems to slightly reduce the rate of loss in the latter. With regard to the compound tissue—compact-spongy, the changes which its conductivity undergoes present simply a varying mean of those of its two components. After long exposure to the air, the bone being well dried, the conductivities of compact and of spongy tissue are found to closely approximate each other.

*Experiments on Brain.*

The experiments on this tissue had reference only to the changes of its conductivity, due to exposure to the air, and to the effect of moisture and fresh animal liquids on these changes.

Like liver and kidney, the tissue of brain quickly loses its power of conduction after death, and neither moisture or fresh animal matter can restore this loss, although they may diminish its rate.

## II. "Further Researches into the Function of the Thyroid Gland and into the Pathological State produced by Removal of the same." By Professor VICTOR HORSLEY, B.S., F.R.C.S. Communicated by Professor MICHAEL FOSTER, M.D., Sec. R.S. Received December 10, 1885.

In December, 1884, I showed that the thyroid gland was intimately connected with the process of mucin metabolism, that if the thyroid gland in monkeys was removed with antiseptic precautions (the same ensuring healing of the wound in three days) the consequences to the animal were—(1) symptoms of general nervous disturbance evidenced by tremors, paroxysmal convulsions, functional paralysis, mental hebetude, and finally complete imbecility; (2) profound anæmia coupled with leucocytosis; (3) all the symptoms of the disease discovered within the last decade and termed myxœdema; (4) that just as in the acute form of the disease just named there was found to be a great accumulation of mucin in the connective tissues throughout the body (mucinoid degeneration), and in the blood, and as a consequence the same post-mortem appearances; (5) that at the same time there was a great activity in the mucin-secreting glands, and, further, that the parotid gland under these abnormal circumstances secreted mucin in large quantity, the gland cells at the same time disintegrating.

During the past year I have confirmed my previous observations, and greatly extended them, and have firm basis for my original opinion that the function of the thyroid gland is indispensable to the higher animals, and that it is duplex, since, in the first place, it regulates the formation of mucin in the body; and, in the second